Separation of Data Path and Data Flow Sublayers in the Transport Layer
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Smart Network from End-to-End Principle

• End-to-End Principle
  • Dumb network with smart end-hosts

• Smarter network \(\rightarrow\) Non-standardized (or ad-hoc sometimes) architecture for intra-domain services
  • QoS
    • DiffServ
    • Segment routing
  • Middlebox
    • Firewall
    • Content caching, Transcoding
    • TCP acceleration
  • New distributed computing paradigm
    • Pub/sub model for machine-to-machine communication
    • Edge computing
    • In-network computing

- path-aware but transparent
- e.g., force rerouting to a waypoint with policy-based routing
- e.g., overlay networking
Transport Layer Functionality: Data Path vs. Data Flow

• Data Path
  • Trajectory & waypoint handling
  • Bidirectional connection
  • Resource monitoring (e.g., congestion)
  • Congestion control
  • Data flow multiplexing
  • Packet duplication for packet loss recovery (like FEC)

  → Stateless or per-path/per-connection states

• Data Flow
  • Retransmission for reliable data communication
  • Flow control (buffer management)
  • Flow prioritization
  • End-to-end security
  • Inverse multiplexing for multipath protocols

  → Per-flow states
Use Cases

• Multipath transport protocols
• Congestion control acceleration
• In-network computing
• Flow arbitration
• etc...
In-network Computing

- In-network computing
  - Compute chain
    - Active network
    - Service function chaining
  - Data aggregation and redistribution
    - All-Reduce in distributed deep learning
Stateless per-packet in-network computing

ECMP can be leveraged if the in-network computing routers do not store any states.
Stateful per-packet in-network computing

A waypoint must be designated and controlled; i.e., stateful for data paths but stateless for data flows
Stateful per-packet in-network computing

Policy-based routing,

Different programs
More complex computing; e.g., per-flow in-network computing

Policy-based routing, Segment routing, etc. (w/ flow classification)

A waypoint must be designated and controlled.
In-network computing router must be aware of flows.
More complex computing; e.g., per-flow in-network computing

- Compute+Buffer
- Policy-based routing,
- Same program
- IP router
- End-host
- A waypoint must be designated and controlled.

Layer Diagram:

- Application Layer
- Data Flow Layer
- Data Path Layer
- Internet Layer
- Link Layer

Policy-based routing, e.g., aggregate two consecutive packets per flow

- Same program
- Compute+Buffer
Summary & Next Step

• Summary: Separation of data path and data flow layers
  • Data path: Aware of network resources and trajectory or waypoints
  • Data flow: Aware of computing resource and flow-level integrity

• Next Step
  • Improve the I-D
    • Add analysis of existing protocols
      • e.g., TCP’s ACK for congestion control and integrity
        • Existing TCP accelerators need a buffer to send back an ACK on behalf of receivers
    • Add more use cases and examples
  • Protocols for data path and data flow layers